Final Technical Report

SUMMER SCHOOLS IN NUCLEAR CHEMISTRY

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Submitted by: Sue B. Clark
Washington State University
Fulmer 26
Pullman, WA 99164-4630

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Background

Since the late 1970's, there has been concern about the training of scientists in nuclear areas. The American Chemical Society's Committee of Professional Training has, for several decades, included coursework in nuclear and radiochemistry as an important elective option for an ACS-approved BS degree in chemistry [1]. Education and training in nuclear chemistry and radiochemistry has been a focus of the American Chemical Society, and its Division of Nuclear Chemistry and Technology (NUCL Division). To address concerns expressed by division members about the perception of declining vigor and magnitude of academic training in this area, the NUCL Division conducted a national survey on the status of training of nuclear and radiochemists in 1977-1978 [1]. They concluded that the academic population of faculty members and graduate students was indeed declining, and that the number of PhD degrees awarded in nuclear and radiochemistry was inadequate to meet the needs of society.

The Summer Schools in Nuclear and Radiochemistry were initiated to help address the need for an undergraduate pipeline into radiochemistry and chemical physics academic programs. Started in 1984 at San Jose State University and expanded to the Brookhaven National Laboratory site in 1989, the summer schools program has been funded by the US Department of Energy, Office of Basic Energy Sciences and has hosted over 400 undergraduate students since its inception. The summer schools are operated under the auspices of the American Chemical Society's Division of Nuclear Chemistry and Technology, which provides the intellectual oversight of the summer schools program.

Detailed histories of the Summer Schools in Nuclear and Radiochemistry can be found in two publications [2,3].

Description of Summer Schools

The American Chemical Society's Summer Schools in Nuclear and Radiochemistry were held at Brookhaven National Laboratory (Upton, NY) and San Jose State University (San Jose, CA) during the award period February 1, 2002 to January 31, 2007. The Summer Schools are intensive, six-week program involving both a lecture component covering fundamental principles of nuclear chemistry and radiochemistry and a laboratory component allowing hands-on experience for the students to test many of the basic principles they learn about in lecture. Each site hosted 12 undergraduate students annually, and students received coursework credits towards their undergraduate degrees. Up to 7 student credit hours were earned at San Jose State University, and Brookhaven students received up to 6 college credits through BNL's management partner, SUNY Stony Brook. Funding from the award period covered travel, housing, educational expenses, and student stipends, for the 24 undergraduate participants. Furthermore, funding was also used to cover expenses for lecturers and staff to run the programs at the two facilities. The students were provided with nuclear and radiochemistry training equivalent to a three-hour upper-level undergraduate course along with a two-hour hands-on laboratory experience within the six-week summer period. Lectures were held 5 days per week. Students completed an extensive laboratory sequence, as well as radiation safety training at the start of the Summer Schools. The summer school curriculum was enhanced with a Guest Lecture series, as well as through several one-day symposia and organized field trips to nuclear-related research and applied science laboratories. This enrichment afforded an opportunity for students to see the broader impacts of nuclear science in today's world, and to experience some of the future challenges through formal and informal discussions with leaders in the diverse fields represented by nuclear chemistry and technology.

Methodology Used

The Summer Schools were held during a six-week period starting in mid-June of each year. Twelve students were selected by the National Director, in consultation with 3-4 members of the ACS Division of Nuclear Chemistry and Technology, to participate at each of the two sites: San Jose State University (SJSU) and Brookhaven National Laboratory (BNL). Sue Clark and Ken Nash from Washington State University served as co-National Directors for the award period February 1, 2002 to January 31, 2007.

Prof. Herbert Silber served as site director at SJSU, and Drs. Kathy Kolsky and Richard Ferrieri served in the same role at BNL. The course syllabus for lectures included the following topics: historical perspective, the atomic nucleus, decay modes, and masses; kinetics, interaction of radiation with matter, and radiation detectors; nuclear forces, nuclear structure, and nuclear models; nuclear reactions (including fission); and, applied nuclear science, including (but not limited to): actinide chemistry, environmental radiochemistry, nuclear medicine, nuclear power, radioisotope production, and radiotracers. Laboratory modules will cover the following nuclear and radiochemistry methods: radiation counting (GM tubes, NaI, scintillation counters, and Ge and Si solid state detectors), counting statistics, radiochemical separations (solvent and column extractions), half-life determination, radiation attenuation, radioimmunoassay, neutron activation analysis, and radiopharmaceutical synthesis.

Example course syllabi for the 2005 programs at SJSU and BNL are provided in the appendix.

As noted earlier, the summer school experiences were greatly enhanced by extracurricular activities that include: guest lectureships, special symposia covering nuclear medicine, environmental remediation and graduate and employment opportunities in nuclear science and technology, and field trips to basic and applied nuclear science laboratories near the school locale. SJSU students visited Lawrence Berkeley National Lab, Lawrence Livermore National Lab, the Stanford Synchrotron Light Source and the PET Center at UC San Francisco. BNL students visited the Relativistic Heavy Ion Collider, the Brookhaven Linac Isotope Producer, the BNL Center for Translational Imaging, the National Synchrotron Light Source, Memorial Sloan-Kettering Cancer Center, and the Nuclear Structure Laboratory at State University of New York at Stony Brook.

Facilities and other resources

Lectures and laboratory modules at BNL were held in Building 801, which is home to the research isotopes program. The recently renovated lecture room was available for the full six weeks of the summer program. Two laboratory rooms house separately the spectroscopy and radiochemistry experiments. The BNL site had sufficient housing available on-site to accommodate both students and guest lecturers. BNL hosts to a number of other summer student programs, and their Office of Educational Programs (OEP) provides assistance with student orientation. The students also make use of some of the cutting-edge research facilities at BNL, for example, students were permitted access to the positron emission tomography (PET) imaging facility and synthesized ^{18}F-labeled compounds typically used for PET diagnostics.

The Summer school activities at San Jose State University (SJSU) were held at the Nuclear Science Facility housed on-campus in Duncan Hall. Two laboratory rooms were available for radiochemical synthesis (Room 185) and spectroscopy (Room 184). A lecture room was also available for the six-week duration of the program. In addition, the program had access to the neutron and gamma irradiation facilities housed at the Nuclear Science Facility. Students and TAs were housed at SJSU at the International House (I-House), located within a 5-minute walk of the SJSU campus.

Equipment

Students at the BNL site has access to 15 desktop computers, 1 laptop computer, an LCD projector, 4 printers (2 laser printers and 2 inkjet color printers), 6 HpGe detectors (2 owned by the summer school project; 2 on loan from BNL Medical group; 1 on loan from Los Alamos National Lab; 1 on loan from Clark University) with associated NIM electronics and 4 ADC/MCA gamma spectroscopy cards interfaced to desktop PCs, 4 NaI(Tl) detectors with associated NIM electronics, 3 spare NaI(Tl) detectors, 7 Geiger Mueller tubes, 1 x-ray source with 2 available x-ray detectors. The BNL Site Director also arranged to have several pieces of equipment from the BNL PET program available to the summer school program, including a Ge well counter, a Packard liquid scintillation counter, a radio TLC imager, and a

phosphor plate imager. A number of miscellaneous NIM modules were loaned to the BNL Site Director from the PET and Medical Isotopes programs.

The equipment available in the SJSU radiochemistry laboratory included 9 centrifuges, 4 balances, a Beckman LS6500 alpha/beta counter, a Packard Tricarb alpha/beta counter, and a Packard Cobra II gamma counter. The counting laboratory contained 9 desktop computers equipped with the Maestro ADC/MCS spectroscopy cards, 6 Ortec Soloist alpha counters, 3 HpGe detectors, 6 NaI detectors, 5 Geiger Mueller tubes, 3 proportional counters, 6 SpecTech ST 3600 Counters with absorber kits, and the necessary NIM electronics to operate the available detector systems. The Nuclear Science Facility at SJSU also provided 2 Ludlum M-44 hand/foot counters, 20 hand-held GM detectors, and a Helegson whole body counter for personnel monitoring.

Demographics of previous attendees

The introduction of a $3,000 student stipend at the start of the last renewal period in 2002 proved critically important in making the summer schools competitive with other summer research programs, such as the NSF sponsored Research Experience for Undergraduates, which also pay stipends. Evidence for the positive impact of the student stipends has been an increasing applicant pool (up to 84 completed applications in 2005) and the increasing GPAs of the student participants (average participant undergraduate GPA was 3.8/4.0 in 2005). Nearly all the student participants have been involved in some undergraduate research project before attending the summer school program. Additional details on the two most recent summer school classes are provided in Table 1.

Table 1. Demographics of Nuclear and Radiochemistry Summer School Classes of 2002 – 2006.

	Class of 2002	Class of 2003	Class of 2004	Class of 2005	Class of 2006
Gender (male/female)	15/9	15/9	15/9	15/9	11/13
College Type (small college/research university)	6/18	15/9	12/12	14/10	11/13
Undergraduate Major					
Chemistry		21	13	14	18
Physics		0	5	5	1
Dual Chemistry/Physics		0	2	3	3
Chemical Engineering		2	2	1	1
Biochemistry/Biophysics		1	2	1	1

A complete listing of former summer school participants and their home undergraduate institutions is available on the ACS Division of Nuclear Chemistry and Technology webpage [4].

Evaluation

The summer school is a long-term investment by the U.S. Department of Energy (DOE) to maintain a critical knowledge base of nuclear chemistry and radiochemical methods required to meet national needs in defense, medicine, environmental remediation, energy development, and fundamental research. For example, the students who attended the 2006 summer schools and decide to pursue a career in nuclear chemistry or technology will appear in the DOE workforce in 7-10 years. As such, it is a challenging task to quantify the impact that the 37 NCSS graduating classes (16 at BNL, 21 at SJSU - representing more than 400 students) might have had to date and how those impacts might be amplified in the future.

To the best of our knowledge, every participant in the summer school programs has continued with some post-baccalaureate education, either medical school, graduate school, or other type of professional school. Though follow up demographic facts on all NCSS graduates are incomplete, the recent graduates of the

NCSS who are presently in graduate school in university research programs that emphasize at some level nuclear and radiochemistry include

- Erin Finn (2002), Washington State University, Environmental Chemistry
- Greg Severin (2002), University of Wisconsin, Madison, Nuclear Physics
- Andi Choiniere (2003), Washington State University, Environmental Chemistry
- Dustin Demoin (2004), University of California, Berkeley, Actinide Chemistry
- Corey Hines (2004), University of Alabama, Analytical Chemistry
- Kiel Holliday (2004), University of Nevada at Las Vegas, Radiochemistry
- Jill Pinter (2004), Michigan State University, Nuclear Chemistry
- Justin Roper (2004), Duke University, Medical Physics
- Christopher Seyfert (2004), University of Wisconsin, Madison, Nuclear Engineering
- Nicholas Smith (2004), University of Nevada at Las Vegas, Radiochemistry
- Stephanie Wissel (2004), University of Chicago, Nuclear Physics
- Zachary Kohley (2005), Texas A&M University, Nuclear Chemistry
- Amy Ratliff (2005), Clemson University, Environmental Radiochemistry
- Jenifer Shafer (2005), Washington State University, Radiochemistry

What should be clear from the above listings is that by attracting the "best and the brightest" to the field of nuclear science, there will be a positive impact on the field in the long term, as these are the students who will emerge as the scientific leadership of tomorrow. The participating students have had a chance to become better informed on the fascinating field of nuclear and radiochemistry and they will be able to participate intelligently in discussions on nuclear science issues that might arise in the future. In this sense, the community of nuclear and radiochemists and the nation as a whole benefits from the continuation of the summer school educational experience.

Bibliography

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3. "The Department of Energy/American Chemical Society Summer School in Nuclear and Radiochemistry at San Jose State University," W.F. Kinard and H.B. Silber, J. Radioanalyt. Nucl. Chem. 263, 155 (2005).

4. http://www.cofc.edu/~nuclear/nukess.html